

ABSTRACT

A lesson that we have learned from the pandemic caused by coronavirus is that solutions in health require coordinated actions. Beside this and other (re)emerging infectious diseases, Spain and Europe are suffering a plethora of disorders that are currently acquiring epidemic dimensions, including cancer, rare diseases, pain and food allergies, among others. New tools for prevention, diagnosis and treatment need to be urgently designed and implemented using new holistic and multidisciplinary approaches involving researchers, clinicians, industry and all stakeholders in the health system. The CSIC is excellently positioned to lead and coordinate these challenges in Biomedicine and Health.

KEYWORDS

biomedicine	therapies	diagnostic tools
cancer	chronic diseases	

CHALLENGES IN BIOMEDICINE AND HEALTH

Topic Coordinators

Mario Delgado (Instituto de Parasitología y Biomedicina Lopez-Neyra),
María Moros (Instituto de Ciencias de Materiales de Aragón)

EXECUTIVE SUMMARY

Despite significant improvements in research, detection and treatments in recent decades, a considerable number of complex diseases have acquired epidemic dimensions and nowadays represent major health, economic and social burdens for our societies. Cancer, emerging and re-emerging infectious diseases, food allergies and rare diseases affect millions of Europeans, and all of them share the urgent need for new strategies that must be implemented at three different levels: basic research level, translational/clinical level and public/social level.

1. Basic scientific level. Because we will only cure what we fully understand, it is mandatory a better comprehension of molecular and cellular mechanisms of these disease from a patient-oriented perspective: study of genetic and epigenetic mechanisms involved in tumor initiation tumor evolution (metastasis cascade), mechanisms that pathogens use to infect and how the host responds to infection, molecular mechanisms of antimicrobial resistance and its evolution, genetic and physiological defects in rare diseases, mechanisms involved in immune tolerance against food components and novel pain targets/pathways with disease-modifying potential between others.

2. Translational/clinical level. It is obvious that we need a comprehensive view of the disease at the patient-level to translate research to the patient bedside, in order to implement new tools for early diagnosis and effective/safe

treatments of the disease and to ensure long-term well-being of patient. Development of vaccines against viral/bacterial threats, identification of biomarkers for drug resistance, cancer, rare diseases and chronic pain, new strategies to enhance host immune responses against pathogens, faster methods of detection of food allergens, repurposing drugs for untreated diseases are some of the challenges that we must face in a short-term frame. The support of stable and accessible technical platforms (omics, big data, data mining, machine learning,...) will catalyze the development of these challenges together with a real and immediate translation to the clinical practice of innovative ways of diagnosis by medical imaging and biosensors as well as of advanced gene and cell therapies, tissue engineering and nanoparticles.

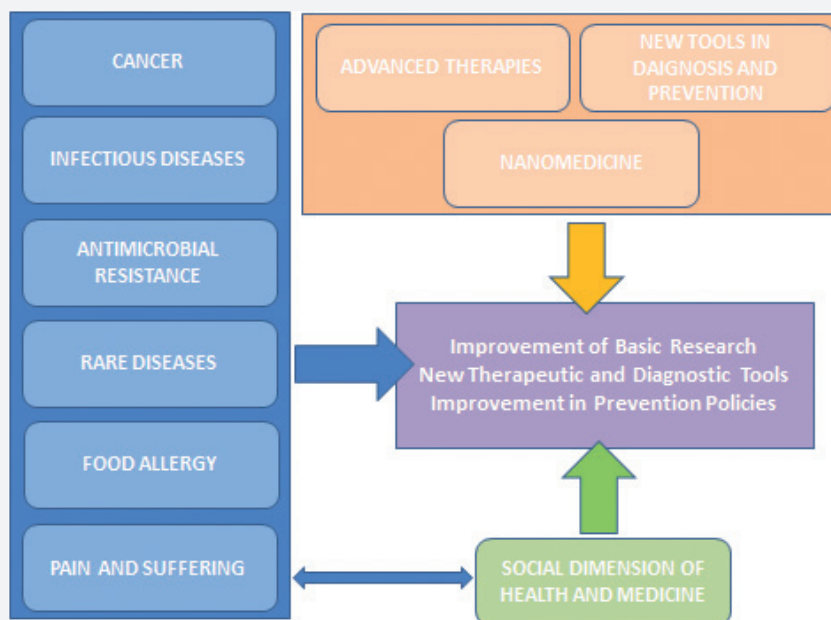
3. Social level. Because all these diseases represent health global problems, every strategy directed to solve them must include the analysis of social dimension as a challenge itself. Understanding concepts such as socio-economic determinants of health (poverty/income inequality, education, gender), complexity of healthcare policies and health systems, migratory currents, alimentary habits, globalization and urban overcrowding, visibility of research institutions by society, researcher-clinician-patient relations is critical for example to improve surveillance systems and prevent epidemic emergent and re-emergent infectious diseases, to manage chronic pain, cancer and rare diseases as a public health problem or to adequately progress in advances therapies.

Toward this goal, we need innovative types of synergistic cooperation by researchers, clinicians, industry and other actors of health system such as health and regulatory agencies, research organizations and patient advocates. Only through this inter- and multidisciplinary approach we will succeed in making real impact in the lives of millions of Europeans. Given its strong research base, the CSIC is well positioned to address these health system needs and capitalize its human and technical resources to become a major player in Biomedicine from a research, a health-oriented, and a policy-making perspective, and to participate in international initiatives for improving prevention, diagnosis and treatment of diseases of global impact.

INTRODUCTION

The present strategic topic aims at giving an overview of the current status and challenges of some important biomedical applications. Biomedicine can be defined as the application of basic sciences to solve problems in clinical

FIGURE 1—Challenges that currently represent a major health, social and economic burden for our society that are considered in this strategic topic



medicine, merging the aspects of medicine with other disciplines such as biology, biochemistry or biophysics. Widely considered as an umbrella term of modern medical research, it includes a vast range of scientific and technological approaches that try to find new treatments and diagnostic tools to improve health, cure illnesses and increase our quality of life. Consequently, biomedicine has a deep impact in our lives.

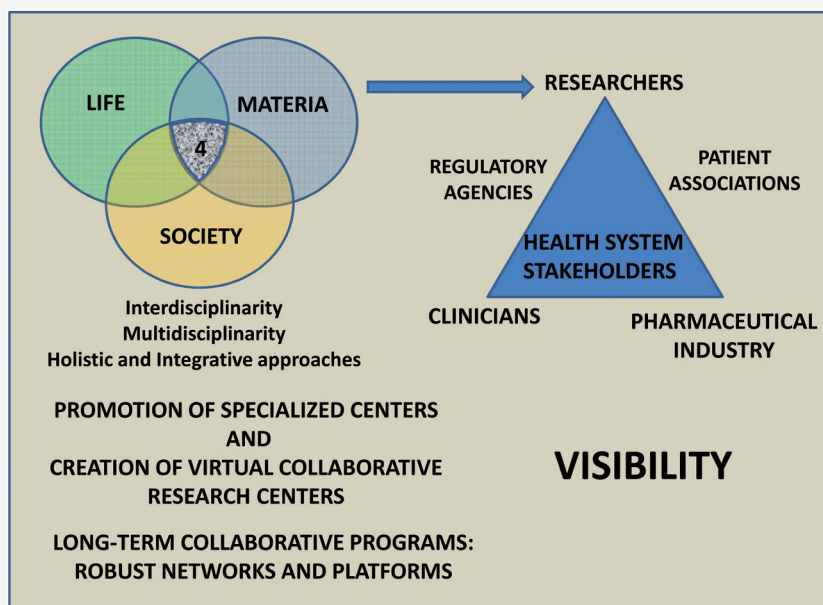
The biomedical field has witnessed outstanding advances in the last decades as a consequence of the progresses in different fields such as cell biology, biochemistry, biomedical engineering, genetics or microbiology among others. In many cases, interdisciplinary approaches are needed to struggle with the diseases. For instance, some time ago death rate caused from cancer started to increase. In that moment cancer research received considerable funding, but neither the causes of death neither the treatments were evident. Only when this research was combined with other disciplines such as

molecular biology studies, major breakthroughs were accomplished. Something similar happened with AIDS in the 1980s.

Despite major advances in health care over the past several decades, there are many complex problems and challenges that still need to be faced. Some of the challenges that currently represent a major health, social and economic burden for our society are considered in this strategic topic (Figure 1):

- i. Cancer is the first and second cause of death among men and women in Spain respectively, and it is forecasted that the cases will double by 2040. Many patient and scientific associations have set the goal of improving the survival rates of cancer patients from the current 55% to 70% by the year 2030 (Challenge 1).
- ii. Emerging and re-emerging infectious diseases such as influenza, HIV/AIDS, malaria, SARS-CoV-2, etc. account for a quarter to a third of estimated deaths worldwide, about 15 million of annual deaths. Resistance to antibiotics, farming activities, environmental and societal changes have favoured the rapid spread of these infections, representing a serious concern in Europe. Of note, infections caused by multi-drug resistant pathogens are considered one of the top three threats of global health (Challenges 2 y 3).
- iii. Rare diseases affect to near 3 million patients in Spain. Because pharmaceutical companies generally underserve them, there is an increasing societal pressure to develop novel diagnosis and therapy methods (Challenge 4).
- iv. Chronic pain has acquired epidemic dimensions from the mid-20th century, being the most common complaint for which individuals seek medical treatment. In many cases current treatments have serious adverse effects or lead to drug abuse, which converts chronic pain in a major medical and societal challenge (Challenge 5).
- v. The prevalence of food allergies in the general population has been roughly estimated to be around 2-4% in adults and 6-8% in children. As the only effective strategy is to avoid the food that causes the allergy, food allergies have a great impact in the quality of life. Food producers must ensure that all the allergens are identified in the labelling. However, traces of allergens due to cross-contaminations are difficult to detect and can pose a health problem. More sensitive and fast detection methods for allergen control that guarantee the security to the consumers are needed (Challenge 6).

FIGURE 2—Strategy and interactions that must be applied and implemented in order to reach the main challenges in biomedicine and health



Currently it is clear that to tackle the majority of these scientific challenges a multifaceted strategy will be needed. Understanding the molecular processes that underlie the diseases, the physiopathology, risk factors and associated societal burden will ease the progress of therapies and diagnosis to cope with them. For instance, machine learning, artificial intelligence and -omics will help to make more accurate decisions regarding the diagnosis, therapies and prognosis in the future. Many of these diseases could greatly benefit from the use of advanced therapies to treat them (Challenge 7). Gene therapy is a powerful tool that offers the potential to cure patients with serious or fatal conditions by engineering or editing the genome. Cell therapy hold great promise on regenerative medicine and biomaterials can revolutionize the way to approach injured tissues. In addition, the development of new biomarkers for early diagnosis of disease and new methods for diagnosis is of paramount importance (Challenge 8). For instance point of care biosensors and wearable devices to monitor health and disease in a less invasive manner will have a profound global socioeconomic impact. In this sense, Nanomedicine, is a truly interdisciplinary field that holds a tremendous

potential for the development of new therapies and diagnosis tools because of the unique properties of nanomaterials when compared with bulk materials (Challenge 9).

Although the topics of the aforementioned Challenges vary widely, we can expect that multidisciplinary teams will be needed to face them, as well as the cooperation between different actors such as researchers, clinicians and stakeholders. Further, health equity must be considered when developing health policy and programmes, as health is considered as a universal Human Right that must be analysed by integrating social, physical and psychological aspects (Challenge 10).